

## REMARKS

Claims 9-11 are currently active.

Claim 9 has been amended. Antecedent support for these amendments “of less than .010 inches” is found on page 9, line 9. These changes are believed consistent with the Examiner’s comments in the last Office Action in the “Response to Arguments” section.

Claim 9 has been amended to obviate the rejection under 35 U.S.C. 112.

The Examiner has rejected Claims 9-11 as being unpatentable over JP6-256067 (Shimpo) in view of Litton and Shinoda. Applicants respectfully traverse this rejection.

In the patent by Shimpo- JP 6-256067, only the development of a joining compound is addressed with no regard to the joint geometry. In particular, joint thickness is not addressed. Joint thickness, substantially impacts the amount of joint shrinkage and hence, joint strength and the porosity. Porosity effects the degree of hermiticity, which is also not addressed in JP 6-256067. In JP 6-256067 there is no information related to a joint design and nothing specifically on what is a suitable taper. A joint thickness has to be developed for each joining material and for each ceramic to be joined. As stated on page 9, lines 9-11 of the specification of

the above-identified patent application, a “joint thickness of less than .010 inches” produces a stronger joint. The applied art of record does not teach or suggest this limitation.

Combining Litton joining method, which applies to brazing ceramic to metal as described above does not apply to the joining of ceramics to ceramics. Shimpo’s compound with no specification on joint thickness produces weak joints in bending strength of 80 MPa at 1200°C whereas in the claimed joint more than 100% increase in bending strength is obtained by proper control of joint thickness.

The patent: Litton 2,972,808 utilizes a brazing alloy (5-15 wt % nickel + 95-85 wt % copper, alloy melting temperatures 1140-1180 °C, respectively) for bonding a ceramic (alumina) (coated with 80-90 wt % tungsten + 10-5 wt % iron + 10-5 wt % manganese) to metal (Kovar) to form a taper joint[“Analysis of Physiochemical Properties of Copper-Nickel System”, Kararov, V.V. et al, Dokl. Phys. Chem, 1992].

Litton 2,972,808 is inherently a different joining process than the claimed invention. In the claimed invention, the joining occurs by growing silicon carbide molecules into a structural ceramic joint which creates a matched thermal expansion coefficient and is chemically inert (oxidation resistant out to 1600 °C).

In the Litton patent, some of the metals (tungsten and copper) will restrict the service temperature to low values ( $<700^{\circ}\text{C}$ ) due to rapid oxidation in air. Tungsten in air at  $1100^{\circ}\text{C}$  for only 1 hour has been measured; the oxidation rate of  $1000\text{ g/m}^2$ . There is almost no tungsten metal left after 1 hour.

Additionally, the thermal expansion coefficient of Kovar is well matched to alumina up to about  $550^{\circ}\text{C}$ , but after  $550^{\circ}\text{C}$  Kovar expands much faster than alumina thus creating joint stresses which further restricts the use of this type of joint [pgs 322-324, Handbook of Electron Tube and Vacuum Techniques, Fred Rosebury, American Institute of Physics 1993].

The motivation of the Litton patent is described in his own words: "Although ceramic-to-metal seals manufactured according to the foregoing process may function satisfactorily the process is carried out carefully, there are several inherent disadvantages which detract from the utility of the process and of the articles formed thereby. Firstly, from the standpoint of the article per se, when the seal is made to the flat end of the ceramic cylinder the seal is frequently weak structurally owing to the fact that its area is limited to the cross-sectional area of the cylinder. Similarly, where the seal is made to the lateral periphery of the cylinder, the seal frequently will leak or form gas traps which subsequently cause failure of the vacuum tube or other device in which it is utilized, one reason for this form of failure being that it is difficult to bring the ceramic and the metal to which it is to be sealed into uniform engagement. From the

process standpoint, furthermore, the prior art process set forth hereinabove requires very precise machining of the ceramic and metal parts in order to assure even a reasonably good seal.”

It is submitted the Examiner has found the word taper used in one context (namely, brazing ceramic to metals) and has applied that word to a different context (ceramic to ceramic joining). It is important to understand that the reason for a need in one context does not necessarily apply to another context.

There is a fundamental difference as to why one forms a tapered ceramic to metal braze joint (Litton) compared to why one forms a tapered ceramic to ceramic bond joint where bonding is done by as grown ceramic material (claimed invention). For ceramic to metal there is generally a mismatch in the thermal expansion coefficient between braze material and the ceramic, mismatches as small as 10% create large stresses which can break the ceramic, thus it is necessary to keep the braze material thin so as to plastically deform under the stress. For brazing metal, thin generally means less than or equal to 0.004 inches~100 microns of a malleable braze alloy. **The tapering in a ceramic to metal braze joint provides a uniform area with a thin joint to minimize stress induced by a mismatch in the thermal expansion coefficient (as in Litton).** To look at this differently, if the brazing material and the joining metal had an identical thermal expansion coefficient as the joining ceramic over the entire temperature range of use then

both the braze material and the metal to be joined can be arbitrarily thick. That is, no stresses will build up in the ceramic, thus no breakage will occur. This of course is not reality.

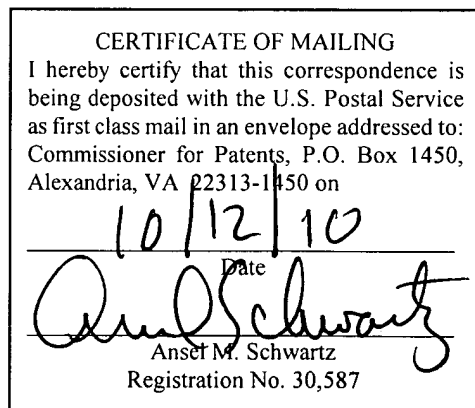
Now, in the case of the ceramic to ceramic joint with a joining compound that matches the thermal expansion coefficient of the to be joined ceramics, as is the case in the claimed invention, one might conclude that the joint material could be arbitrarily thick. This would be exactly wrong. The reason being is the thicker the bonding ceramic is the larger are the voids that are formed, larger voids makes a weaker ceramic bonding material thus weaker joints when bonding ceramic to ceramic. Void formation is an inherent process when producing the bonding material. That is bonding material starts out as a malleable solid or a liquid made up of, in the simplest case, atoms of silicon, carbon and hydrogen. This joining material is for example bonding silicon carbide ceramic to silicon carbide ceramic. When this compound is heated correctly, just the hydrogen is removed from the compound, leaving behind pure silicon carbide which grows into crystals that bond together the silicon carbide ceramic to silicon carbide ceramic. What results when the mass of hydrogen is liberated from the joining compound are voids where the hydrogen was previously located. Furthermore, the pure silicon carbide joining material is a solid that cannot flow to fill the voids. The size of the void space can range from 10-60 % of the dimensions of the bonding material. This range of void size is controlled by the heating rate. By keeping the absolute value of the joint thickness small (less than 0.01 inches~250 microns), then the voids will be small, hence a stronger bond

will be formed. The tapering in a ceramic to ceramic joint with the same ceramic for bonding provides a uniform area with a thin joint to maximize joint strength by reducing the size of the voids (as in the claimed invention).

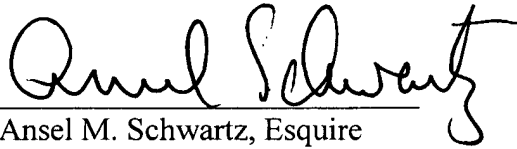
It is respectfully submitted Shinoda does not add anything in relevant part to Litton and Shimpo to arrive at applicants' claimed invention.

Accordingly, Claim 9 is patentable over the applied art of record. Claims 10 and 11 are dependent to Claim 9 and are patentable for the reasons Claim 9 is patentable.

In view of the foregoing remarks, it is respectfully requested that the outstanding rejections and objections to this application be reconsidered and withdrawn, and Claims 9-11, now in this application be allowed.



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